



Revised Tables 9 and 10: Ray Avenue-BLR-Streamlined Risk Evaluation 

Kelly Schumacher to: Patrick

01/28/2013 02:57 PM

Cc: Julie VanHorn, Catherine Barrett

Patrick,

I concur with the changes you have made to the risk estimates in Tables 9 and 10, as well as the changes in the Exhibits. (There is one minor typographical error in Exhibit IV, benzo(a)anthracene, ingestion, where the exposure concentration is given as both 1.45E-05 and 1.54E-05. You might change this so that the correct value is used both times.)

I have no further comments on the calculations. I believe you will be incorporating these changes in Section 6 (Conclusions).

Kelly

Kelly Schumacher, Toxicologist  
Environmental Services Division  
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"Patrick"

Kelly-

01/28/2013 09:12:26 AM

From: "Patrick" <pkennedy@shifrinandassociates.com>  
To: Kelly Schumacher/R7/USEPA/US@EPA  
Date: 01/28/2013 09:12 AM  
Subject: RE: Review of Tables 9 and 10: Ray Avenue-BLR-Streamlined Risk Evaluation

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Kelly-

Thank you so much for your help with all of this. I have made the appropriate revisions to the tables and Exhibit IV. Copies of these tables and Exhibit IV are attached to this email. I just wanted to make sure that you have the same documents that we do when we talk tomorrow. Again, I really appreciate your assistance.

Thanks, Patrick

**From:** Schumacher.Kelly@epamail.epa.gov [mailto:Schumacher.Kelly@epamail.epa.gov]  
**Sent:** Friday, January 25, 2013 10:05 PM  
**To:** Patrick  
**Cc:** Barrett.Catherine@epamail.epa.gov; VanHorn.Julie@epamail.epa.gov  
**Subject:** Review of Tables 9 and 10: Ray Avenue-BLR-Streamlined Risk Evaluation

Hi Patrick,

Sorry I am just now replying.

The risk estimates for the commercial/industrial worker, presented in Table 9 are the same values that I derived.

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A few of the risk estimates for the construction worker, presented in Table 10, are slightly different, but I can tell you why. I've attached a color coded version of my Table 10 for you to reference.

- Yellow cells - for all of these, I used an averaging time of 126 days, while you used 127.75 days
- Red cell - the non-cancer HQ for ingestion of acenaphthene is off because the subchronic RfD of 6E-1 mg/kg-day should be used (not 6E-2 mg/kg-day); also I used an AT of 126 days
- Blue cell - the non-cancer HQ for dermal absorption of arsenic is off because the correct ABSd is 0.03, not 0.13; also, I used an AT of 126 days
- Green cells - these values are off because of the differences in the red, blue, and yellow cells, as noted above.
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I hope this is helpful, and I look forward to talking with your group next Tuesday.

Kelly

*(See attached file: Ray Ave\_BLR\_Table 10\_Construction Worker Risk Estimates.xlsx)*

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"Patrick" ---01/25/2013 10:53:24 AM---Kelly -

From: "Patrick" <[pkennedy@shiirinandassociates.com](mailto:pkennedy@shiirinandassociates.com)>  
To: Kelly Schumacher/R7/USEPA/US@EPA  
Cc: Catherine Barrett/R7/USEPA/US@EPA, Julie VanHorn/R7/USEPA/US@EPA  
Date: 01/25/2013 10:53 AM  
Subject: RE: Ray Avenue-BLR-Streamlined Risk Evaluation

Kelly –

Thank you for your quick response. I have attached revised Table Nos. 9 and 10 and the revised Exhibit IV, which also includes the revision to Equation 5-14. In addition, I have also attached the spreadsheets which were used to calculate the values in Table Nos. 9 and 10. Our responses to your comments are as follows.

1. We agree that the non-cancer risk from inhalation of arsenic by commercial workers should be 9.65E-05. This value was shown in the sample calculations in Exhibit III and in the supporting spreadsheet but was incorrectly presented in Table No. 9 as 4.76E-06 in the June 1, 2012 report. The table has been revised to reflect this change.
2. Based on this comment, a review of the spreadsheet indicated that both the exposure concentration and HQ for exposure to naphthalene (non-cancer) were incorrectly presented in Table No. 9. Both the exposure concentration and HQ for naphthalene inhalation by commercial workers (non-cancer) have been revised to reflect the appropriate values. We agree that the HQ for this pathway should be 8.28E-04.
3. N/A
4. We have reviewed Equation 5-14 in Exhibit IV and discovered a typographical error, which caused the VF to be off by a factor of 10. We revised the calculations and agree that the VF for this scenario is 3.24E03. The change to this VF caused the cancer risk for inhalation of naphthalene to change to 2.56E-09. However, based on your comment 5, the cancer risk for naphthalene and all other exposure pathways and chemicals of concern have been revised.
5. The exposure concentrations for each chemical of concern for the construction worker exposure pathways in the June 1, 2012 report were calculated using an exposure frequency (EF) of 90 days and an

exposure duration (ED) of 0.35 years. Based on your comment 5, the exposure concentrations have been revised using an exposure duration of 1 year. The revisions to the exposure concentration equations have changed each exposure concentration value presented in Table No. 10, and therefore, each ICELR and HQ in Table No. 10 changed. The values presented in Table No. 10 have been revised. In addition, the example calculations for the construction worker exposure scenarios, presented in Exhibit IV, have been revised. We agree that the non-cancer risk estimate for incidental ingestion of arsenic is 1.2E-01 (listed as 1.15E-01 in Exhibit IV and Table No. 10).

6. Table Nos. 9 and 10 have been revised based on this comment.

Once you have had a chance to review these documents, we will finalize a submittal by hard copy. Thanks again for your help and I am looking forward to receiving your comments. If you have any questions or need additional information at this time, please advise.

Thanks, Patrick

**From:** [Schumacher.Kelly@epamail.epa.gov](mailto:Schumacher.Kelly@epamail.epa.gov) [mailto:[Schumacher.Kelly@epamail.epa.gov](mailto:Schumacher.Kelly@epamail.epa.gov)]

**Sent:** Friday, January 25, 2013 10:01 AM

**To:** Patrick

**Cc:** [Barrett.Catherine@epamail.epa.gov](mailto:Barrett.Catherine@epamail.epa.gov); [VanHorn.Julie@epamail.epa.gov](mailto:VanHorn.Julie@epamail.epa.gov)

**Subject:** Re: Ray Avenue-BLR-Streamlined Risk Evaluation

Patrick,

I am cc-ing Cathy and Julie, because they may be interested in your response.

Yesterday, Cathy, Julie, and I met and also concluded that only a few pages of the report would be affected by my comments. We were also thinking it would be more efficient to just make changes to those pages, so that we can finish this up. As long as they are ok with it, I agree it would be most efficient if you send the tables via email for me to review. I have actually set up a spreadsheet to calculate the new risk estimates for Tables 9 and 10. I can send it to you (and cc Cathy and Julie). That way we can compare and make sure our values match.

Kelly

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Kelly Schumacher, Toxicologist  
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"Patrick" ---01/25/2013 09:22:49 AM---Kelly - I have reviewed the January 23, 2012 memorandum regarding the June 1, 2012

From: "Patrick" <[pkennedy@shifrinandassociates.com](mailto:pkennedy@shifrinandassociates.com)>

To: Kelly Schumacher/R7/USEPA/US@EPA

Date: 01/25/2013 09:22 AM

Subject: Ray Avenue-BLR-Streamlined Risk Evaluation

Kelly -

I have reviewed the January 23, 2012 memorandum regarding the June 1, 2012 Streamlined Risk Evaluation for the BLR portion of the Ray Avenue Superfund site located at 4327 Gustine Ave. Based on the comments presented in this

memorandum, I have made the appropriate changes to the report. Only the following portions of the report have been affected by these revisions:

- Page 14 (ED for construction worker is now 1 year)
- Table No. 9 (based on comments 1 and 2)
- Exhibit IV Equation 5-4 (based on comment 4)
- Table No. 10 (based on comments 4 and 5)
- Table Nos. 9 and 10 (based on comment 6)

In addition to these revisions, Section 6.0 (Results and Conclusions) have been revised to reflect these revisions.

I was curious to see if we need to submit an entire report to show these revisions, or if we could just submit the revised pages, tables and exhibit? Also, could I submit these revised documents via email for your review to ensure that these tables are correct? I can also send the spreadsheets detailing the calculations if required.

Thanks,

Patrick Kennedy, P.E.  
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[attachment "A09014.T9.T10.xls" deleted by Kelly Schumacher/R7/USEPA/US]  
[attachment "DOC012513-01252013104134.pdf" deleted by Kelly



Schumacher/R7/USEPA/US] DOC012813-01282013090616.pdf

TABLE NO. 9  
EXPOSURE CONCENTRATION/RISK EVALUATION  
ON-SITE COMMERCIAL WORKER  
4327 GUSTINE AVENUE

**EXPOSURE CONCENTRATION**

Chemicals of Potential Concern	Soil Concentration (mg/kg)	Ingestion		Inhalation		Dermal Contact	
		Carcinogen	Non-Carcinogen	Carcinogen	Non-Carcinogen	Carcinogen	Non-Carcinogen
Acenaphthene	222	NA	2.17E-04	NA	NA	NA	1.86E-04
Anthracene	222	NA	2.17E-04	NA	NA	NA	1.86E-04
Benzo(a)anthracene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Benzo(a)pyrene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Benzo(b)fluoranthene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Benzo(k)fluoranthene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Chrysene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Dibenzo(a,h)anthracene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Fluoranthene	253	NA	2.48E-04	NA	NA	NA	2.12E-04
Fluorene	222	NA	2.17E-04	NA	NA	NA	1.86E-04
Indeno(1,2,3-cd)pyrene	222	7.76E-05	NA	1.33E-05	NA	6.66E-05	NA
Naphthalene	0.594	NA	5.81E-07	8.87E-04	2.48E-03	NA	4.99E-07
Pyrene	222	NA	2.17E-04	NA	NA	NA	1.86E-04
Arsenic	8.62	3.01E-06	8.43E-06	5.17E-07	1.45E-06	5.96E-07	1.67E-06
Chromium	36.6	1.28E-05	3.58E-05	2.19E-06	6.14E-06	NA	NA

**RISK EVALUATION**

Chemicals of Potential Concern	Soil Concentration (mg/kg)	Ingestion		Inhalation		Dermal Contact	
		IELCR	HQ	IELCR	HQ	IELCR	HQ
Acenaphthene	222	NA	3.62E-03	NA	NA	NA	3.11E-03
Anthracene	222	NA	7.24E-04	NA	NA	NA	6.21E-04
Benzo(a)anthracene	222	5.66E-05	NA	1.46E-09	NA	4.86E-05	NA
Benzo(a)pyrene	222	5.66E-04	NA	1.46E-08	NA	4.86E-04	NA
Benzo(b)fluoranthene	222	5.66E-05	NA	1.46E-09	NA	4.86E-05	NA
Benzo(k)fluoranthene	222	5.66E-06	NA	1.46E-09	NA	4.86E-06	NA
Chrysene	222	5.66E-07	NA	1.46E-10	NA	4.86E-07	NA
Dibenzo(a,h)anthracene	222	5.66E-04	NA	1.60E-08	NA	4.86E-04	NA
Fluoranthene	253	NA	6.19E-03	NA	NA	NA	5.31E-03
Fluorene	222	NA	5.43E-03	NA	NA	NA	4.66E-03
Indeno(1,2,3-cd)pyrene	222	5.66E-05	NA	1.46E-09	NA	4.86E-05	NA
Naphthalene	0.594	NA	2.91E-05	3.02E-08	8.28E-04	NA	2.49E-05
Pyrene	222	NA	7.24E-03	NA	NA	NA	6.21E-03
Arsenic	8.62	4.52E-06	2.81E-02	2.22E-09	9.65E-05	8.95E-07	5.57E-03
Chromium	36.6	6.40E-06	1.19E-02	1.84E-07	6.14E-05	NA	NA

<b>Cumulative Pathway Risk</b>	1.32E-03	6.33E-02	2.53E-07	9.86E-04	1.12E-03	2.55E-02
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**SITE WIDE RISK**

<b>CUMULATIVE IELCR</b>	2E-03
<b>HAZARD INDEX</b>	9E-02

TABLE NO. 10  
EXPOSURE CONCENTRATION/RISK EVALUATION  
ON-SITE CONSTRUCTION WORKER  
4327 GUSTINE AVENUE

**EXPOSURE CONCENTRATION**

Chemicals of Potential Concern	Concentration	Ingestion		Inhalation		Dermal Contact	
		Carcinogen	Non-Carcinogen	Carcinogen	Non-Carcinogen	Carcinogen	Non-Carcinogen
Acenaphthene	587	NA	1.98E-03	NA	NA	NA	7.71E-04
Anthracene	587	NA	1.98E-03	NA	NA	NA	7.71E-04
Benzo(a)anthracene	875	1.45E-05	NA	1.85E-04	NA	5.67E-06	NA
Benzo(a)pyrene	1050	1.74E-05	NA	2.22E-04	NA	6.80E-06	NA
Benzo(b)fluoranthene	1180	1.96E-05	NA	2.50E-04	NA	7.64E-06	NA
Benzo(k)fluoranthene	587	9.75E-06	NA	1.24E-04	NA	3.80E-06	NA
Chrysene	905	1.50E-05	NA	1.91E-04	NA	5.86E-06	NA
Dibenzo(a,h)anthracene	587	9.75E-06	NA	1.24E-04	NA	3.80E-06	NA
Fluoranthene	1230	NA	4.14E-03	NA	NA	NA	1.62E-03
Fluorene	587	NA	1.98E-03	NA	NA	NA	7.71E-04
Indeno(1,2,3-cd)pyrene	635	1.05E-05	NA	1.34E-04	NA	4.11E-06	NA
Naphthalene	0.594	NA	2.00E-06	2.15E-04	4.36E-02	NA	7.81E-07
Pyrene	1060	NA	3.57E-03	NA	NA	NA	1.39E-03
Arsenic	10.4	1.73E-07	3.50E-05	2.20E-06	4.46E-04	1.55E-08	3.15E-06
Chromium	36.6	6.08E-07	1.23E-04	7.74E-06	1.57E-03	NA	NA

**RISK EVALUATION**

Chemicals of Potential Concern	Concentration	Ingestion		Inhalation		Dermal Contact	
		IELCR	HQ	IELCR	HQ	IELCR	HQ
Acenaphthene	587	NA	3.30E-03	NA	NA	NA	1.29E-03
Anthracene	587	NA	1.98E-04	NA	NA	NA	7.71E-05
Benzo(a)anthracene	875	1.06E-05	NA	2.04E-08	NA	4.14E-06	NA
Benzo(a)pyrene	1050	1.27E-04	NA	2.44E-07	NA	4.96E-05	NA
Benzo(b)fluoranthene	1180	1.43E-05	NA	2.75E-08	NA	5.58E-06	NA
Benzo(k)fluoranthene	587	7.12E-07	NA	1.37E-08	NA	2.78E-07	NA
Chrysene	905	1.10E-07	NA	2.11E-09	NA	4.28E-08	NA
Dibenzo(a,h)anthracene	587	7.12E-05	NA	1.49E-07	NA	2.78E-05	NA
Fluoranthene	1230	NA	1.04E-02	NA	NA	NA	4.04E-03
Fluorene	587	NA	4.94E-03	NA	NA	NA	1.93E-03
Indeno(1,2,3-cd)pyrene	635	7.70E-06	NA	1.48E-08	NA	3.00E-06	NA
Naphthalene	0.594	NA	3.34E-06	7.31E-09	1.45E-02	NA	1.30E-06
Pyrene	1060	NA	1.19E-01	NA	NA	NA	4.64E-02
Arsenic	10.4	2.59E-07	1.17E-01	9.46E-09	2.98E-02	2.33E-08	1.05E-02
Chromium	36.6	3.04E-07	2.47E-02	6.50E-07	5.24E-03	NA	NA
Cumulative Pathway Risk		2.32E-04	2.79E-01	1.14E-06	4.95E-02	9.05E-05	6.43E-02

**SITE WIDE RISK**

CUMULATIVE IELCR	3E-04
CUMULATIVE HQ	4E-01

## EXHIBIT IV - ON-SITE CONSTRUCTION WORKER

Benzo(a)anthracene (Carcinogen) – 875 mg/kg

### INGESTION

$$ExposureConc = \frac{CA \times IR \times EF \times ED}{BW \times AT_c}$$

$$IR_{soil} = \frac{330mg}{day} \times \frac{1g}{1000mg} \times \frac{1kg}{1000g} = 3.3E-04 \frac{kg}{day}$$

$$ExposureConc = \frac{875 \frac{mg}{kg} \times 3.3E-04 \frac{kg}{day} \times 90 \frac{days}{year} \times 1 year}{70kg \times 70 years \times 365 \frac{days}{year}}$$

$$ExposureConc = 1.45E-05 \frac{mg}{kg-day}$$

$$IELCR = ExposureConc \times SlopeFactor$$

$$IELCR = 1.54E-05 \frac{mg}{kg-day} \times 7.3E-01 \frac{kg-day}{mg}$$

$$IELCR = 1.06E-05$$

### INHALATION (PARTICULATES)

$$ExposureConc = \frac{CA \times ET \times EF \times ED}{AT_c}$$

$$PEF = \frac{Q}{C_{sr}} \times \frac{1}{F_D} \times \left[ \frac{T \times A_R}{556 \times \left(\frac{W}{3}\right)^{0.4} \times \frac{(365-p)}{365} \times \sum VKT} \right]$$

$$PEF = 23.02 \times \frac{1}{0.185} \times \left[ \frac{2,592,000 \times 162.58}{556 \times \left(\frac{12.8}{3}\right)^{0.4} \times \frac{(365-112)}{365} \times 13.716} \right]$$

$$PEF = 5.55E06 \frac{m^3}{kg}$$

$$CA = \frac{Concentration}{PEF} = \frac{875 \frac{mg}{kg} \times \frac{1000 \mu g}{1mg}}{5.55E06 \frac{m^3}{kg}} = 0.1577 \frac{\mu g}{m^3}$$

$$ExposureConc = \frac{0.1577 \frac{\mu g}{m^3} \times 8 \frac{hours}{day} \times 90 \frac{days}{year} \times 1 year}{70 years \times 365 \frac{days}{year} \times 24 \frac{hours}{day}}$$

$$ExposureConc = 1.85E-04 \frac{\mu g}{m^3}$$

$$IELCR = 1.85E-04 \frac{\mu g}{m^3} \times 1.1E-04 \frac{m^3}{\mu g}$$

$$IELCR = 2.04E-08$$

## DERMAL CONTACT

$$ExposureConc = \frac{CA \times SA \times M \times EF \times ED \times ABS_D}{BW \times AT_c}$$

$$M = 0.3 \frac{mg}{cm^2} \times \frac{1g}{1000mg} \times \frac{1kg}{1000g} = 3.00E-07 \frac{kg}{cm^2}$$

$$ExposureConc = \frac{875 \frac{mg}{kg} \times 3300 cm^2 \times 3.00E-07 \frac{kg}{cm^2} \times 90 \frac{days}{year} \times 1 year \times 1 \frac{event}{day} \times 0.13}{70kg \times 70 years \times 365 \frac{days}{year}}$$

$$ExposureConc = 5.67E-06 \frac{mg}{kg \cdot day}$$

$$IELCR = 5.67E-06 \frac{mg}{kg \cdot day} \times 7.3E-01 \frac{kg \cdot day}{mg}$$

$$IELCR = 4.14E - 06$$

## ON-SITE CONSTRUCTION WORKER

Arsenic (Non-Carcinogen) – 10.4 mg/kg

### INGESTION

$$ExposureConc = \frac{CA \times IR \times EF \times ED}{BW \times AT_{NC}}$$

$$IR_{soil} = \frac{330mg}{day} \times \frac{1g}{1000mg} \times \frac{1kg}{1000g} = 3.3E-04 \frac{kg}{day}$$

$$ExposureConc = \frac{10.4 \frac{mg}{kg} \times 3.3E-04 \frac{kg}{day} \times 90 \frac{days}{year} \times 1 year}{70kg \times \frac{126days}{365 \frac{days}{year}} \times 365 \frac{days}{year}}$$

$$ExposureConc = 3.50E-05 \frac{mg}{kg-day}$$

$$HQ = \frac{ExposureConc}{RfD}$$

$$HQ = \frac{3.50E-05 \frac{mg}{kg-day}}{3.00E-04 \frac{mg}{kg-day}}$$

$$HQ = 1.17E-01$$

### INHALATION (PARTICULATES)

$$ExposureConc = \frac{CA \times ET \times EF \times ED}{AT_c}$$

$$CA = \frac{Concentration}{PEF} = \frac{10.4 \frac{mg}{kg} \times \frac{1000\mu g}{1mg}}{5.55E06 \frac{m^3}{kg}} = 1.87E-03 \frac{\mu g}{m^3}$$

$$ExposureConc = \frac{1.87E-03 \frac{\mu g}{m^3} \times 8 \frac{hours}{day} \times 90 \frac{days}{year} \times 1 year}{\frac{126 days}{365 \frac{days}{year}} \times 365 \frac{days}{year} \times 24 \frac{hours}{day}}$$

$$ExposureConc = 4.46E-04 \frac{\mu g}{m^3}$$

$$HQ = \frac{4.46E-04 \frac{\mu g}{m^3}}{1.5E-05 \frac{mg}{m^3} \times \frac{1000 \mu g}{1 mg}}$$

$$HQ = 2.98E-02$$

#### DERMAL CONTACT

$$ExposureConc = \frac{CA \times SA \times M \times EF \times ED \times ABS_D}{BW \times AT_{NC}}$$

$$M = 0.3 \frac{mg}{cm^2} \times \frac{1g}{1000mg} \times \frac{1kg}{1000g} = 3.00E-07 \frac{kg}{cm^2}$$

$$ExposureConc = \frac{10.4 \frac{mg}{kg} \times 3300 cm^2 \times 3.00E-07 \frac{kg}{cm^2} \times 90 \frac{days}{year} \times 1 year \times 1 \frac{event}{day} \times 0.03}{70 kg \times \frac{126 days}{365 \frac{days}{year}} \times 365 \frac{days}{year}}$$

$$ExposureConc = 3.15E-06 \frac{mg}{kg \cdot day}$$

$$HQ = \frac{3.15E-06 \frac{mg}{kg \cdot day}}{3.0E-04 \frac{mg}{kg \cdot day}}$$

$$HQ = 1.05E-02$$

Equation 5-14  
Derivation of the Subchronic Volatilization Factor  
Construction Scenario

**CHEMICAL SPECIFIC PARAMETERS**

Chemical :	<u>Naphthalene</u>	
Organic Carbon Partition Coefficient ( $K_{OC}$ )	<u>2.00E+03</u>	L/kg
Henry's Law Constant ( $H'$ )	<u>1.98E-02</u>	
Diffusivity in Water ( $D_W$ )	<u>7.50E-06</u>	cm <sup>2</sup> /s
Diffusivity in Air ( $D_i$ )	<u>5.90E-02</u>	cm <sup>2</sup> /s

**SITE SPECIFIC PARAMETERS**

Organic Carbon Content of Soil ( $f_{OC}$ )	<u>0.006</u>	g/g
Air-Filled Soil Porosity ( $\theta_A$ )	<u>0.2840</u>	
Water Filled Soil Porosity ( $\theta_W$ )	<u>0.1500</u>	
Total Soil Porosity ( $\eta$ )	<u>0.4340</u>	
Dry Soil Bulk Density ( $\rho_b$ )	<u>1.5</u>	g/cc
Soil Partical Density ( $\rho_s$ )	<u>2.65</u>	g/cc
Inverse Mean Conc at Center of Sq Source ( $Q/C$ )	<u>14.31</u>	(g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )
Exposure Interval (T)	<u>2.59E+06</u>	seconds
Dispersion Correction Factor ( $F_d$ )	<u>0.185</u>	

$$K_d = K_{OC} \times f_{OC}$$

$$K_d = \underline{12.00} \text{ cm}^3/\text{g}$$

$$D_A = \frac{[(\theta_A^{10/3} D_i H') + \theta_W^{10/3} D_W] / \eta^2}{\rho_b K_d + \theta_W + \theta_A \times H'}$$

$$D_A = \underline{5.15E-06} \text{ cm}^2/\text{s}$$

**Equation 5-14**

$$VF_{sc} = \left[ \frac{(3.14 \times D_A \times T)^{1/2}}{2 \times \rho_b \times D_A} \right] \times 10^{-4} \frac{m^2}{cm^2} \times \frac{Q}{C_{sa}} \times \frac{1}{F_D}$$

$$VF = \underline{3242.61} \text{ m}^3/\text{kg}$$